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# Estimating the Accuracy and Precision of Nitrogen Management During Corn Production

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# ESTIMATING THE ACCURACY AND PRECISION OF NITROGEN MANAGEMENT DURING CORN PRODUCTION

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The advent of variable-rate fertilizer applicators has created a need for fertilizer N recommendations that address spatial variability within cornfields. These recommendations must include assessments of where variable-rate applications are likely to be profitable and where they are not. They also must indicate how rates should vary with soil type within fields when variable-rate applications are used.

The problem of developing guidelines would be simple if N fertilizer requirements were proportional to yields. However, recent studies using precision farming technologies indicate that N fertilizer needs are not proportional to published yield potentials, "proven" yields, or observed yields. This leaves some uncertainty as to how recommendations should be developed.

In this paper we propose a method that can be used to assess potential benefits of variable-rate applications and the quality of any given application of N. The method involves using the end-of-season test for cornstalk nitrate (Blackmer and Mallarino, 1997) to assess the accuracy and precision of N applications.

## The Basic Approach

The following six points describe the basic approach to the new method.

1. The end-of-season test for cornstalk nitrate provides a measure of the sufficiency of N for corn growth. It is unique among tissue tests for corn because it can describe sufficiency levels on a range that extends from below optimal to above optimal. Because it characterizes sufficiency levels over the whole range of interest, this test can be used to characterize N sufficiency levels in fields treated with typical rates of N.

2. If N management were "perfect", all plants would have exactly the optimal level of N sufficiency at the end of the season. All samples collected from test areas within fields would have the optimal concentration of stalk nitrate.

3. The accuracy of fertilization (i.e., the nearness of observed stalk nitrate concentrations to optimal stalk nitrate concentrations) can be estimated from the mean of several stalk samples collected within the area fertilized.

4. The precision of fertilization (i.e., the variability in observed stalk nitrate concentrations) can be estimated from the standard deviation of observed stalk nitrate concentrations about the mean.

5. The method gives estimates of accuracy and precision that consider uniformity of N application as well as extent to which rates were adjusted to compensate for losses of N and other important factors.

6. The method can be used within areas of seemingly uniform soil type or in fields with obvious differences in soil type. When used in areas of seemingly uniform soil, variability in stalk nitrate concentrations provides a measure of uniformity of N application. When used on whole fields with obvious differences in soil type, variability in stalk nitrate concentrations can be used to identify soil types that needed more N and soil types that needed less N. This information can be used to develop recommendations for variable-rate applications of N.

### Avoiding Some Technical Problems

Interpretations of the end-of-season cornstalk test are complicated by nonlinear relationships between concentrations of nitrate in stalks and availability of N in the soil. Interpretations are further complicated by a very wide range in results, stalk nitrate-N concentrations often range from <100 ppm to >8000 ppm.

Transforming stalk nitrate concentrations to YB index values can minimize these complications. This can be done by interpolation from the scale on the right or by using the equation below.

$$\text{YB index} = -100 \times \log\left(\log\left(\frac{14000}{\text{stalkN}}\right)\right) + 11.4$$

| Concentration of Stalk Nitrate-N (ppm) | YB Index |
|---|---|
| 36 | -30 |
| 68 | -25 |
| 122 | -20 |
| 204 | -15 |
| 323 | -10 |
| 487 | -5 |
| 700 | 0 |
| 971 | 5 |
| 1298 | 10 |
| 1681 | 15 |
| 2117 | 20 |
| 2600 | 25 |
| 3122 | 30 |
| 3676 | 35 |
| 4251 | 40 |
| 4840 | 45 |
| 5432 | 50 |
| 6021 | 55 |
| 6600 | 60 |
| 7162 | 65 |
| 7704 | 70 |
| 8221 | 75 |
| 8711 | 80 |

### A Survey of the Accuracy and Precision of N Management in Iowa Cornfields

A total of 3100 cornstalk samples were collected in pre-selected patterns from 60 cornfields where the farmer had applied N at a uniform rate. Each sample consisted of ten 8-inch segments of stalk collected between 6 and 14 inches above the ground. These were collected 1 to 4 weeks after black layers had formed on most kernels. Means and standard deviations of stalk nitrate and YB index values were calculated for each field.

Studies over the past 10 years have shown that stalk samples collected from small areas within fields can have an occasional

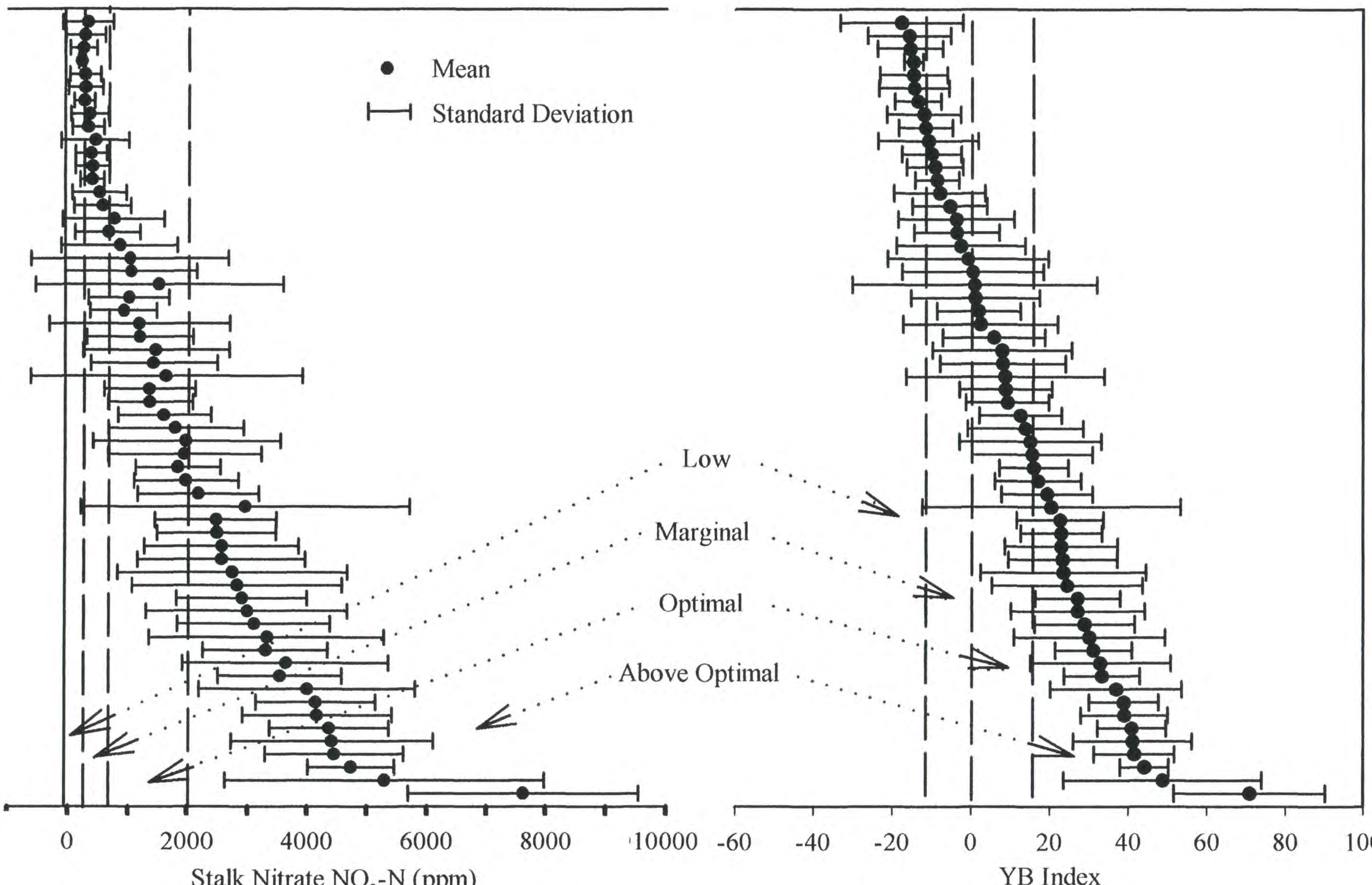


Figure 1. Means and standard deviations of stalk nitrate concentrations and YB index values found during intensive sampling of 60 cornfields in Iowa.

extraordinarily high nitrate concentration due to sampling an area influenced by old manure piles, recent fertilizer spills, or other factors. In order to avoid giving undue importance to such samples, individual observations more than 2 standard deviations from the mean were deleted as outliers (6% of the samples were deleted). The means and standard deviations were re-calculated and plotted in Fig. 1.

Data presented in Fig. 1 showed that many of the fields tested below or above optimal. The results indicate that the potential benefits of improving average rates of fertilization for fields were at least as great as the potential benefits of variable-rate fertilization within fields.

Analyses showed that mean YB index values for fields were not correlated with rates of N application. It seems, therefore, that rates of N fertilization were not adequately adjusted to compensate for losses of N or for other important factor(s) influencing N fertilizer needs.

## Interpretations of Ten-Sample Assessments of Accuracy and Precision

The results shown in Fig. 1 were based on greater numbers of samples than would be practical to collect for routine assessments of accuracy and precision of N management in production agriculture. To enable interpretations of a more reasonable size sample, 207 sets of 10 samples were randomly selected from the fields sampled in 1997. The means and standard deviations of each set were calculated as indicated above. The resulting standard deviations were called "variability index" values. Figure 2 shows the frequency distribution of these values.

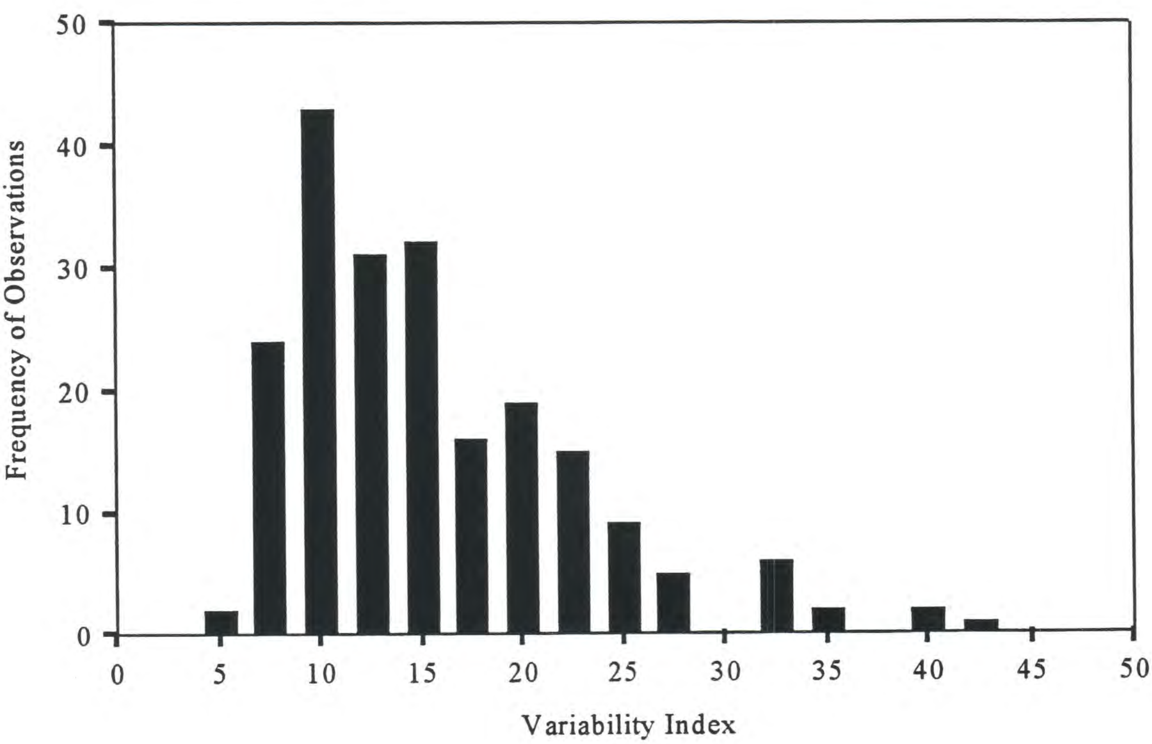


Figure 2. Frequency distribution of variability index values found in 207 sets of 10 cornstalk samples collected within 34 fields in 1997.

Table 2 shows four descriptive categories (i.e., Low, Medium, High, and Very High) characterizing degree of variability in N-sufficiency as indicated by a set of 10 samples. The scale includes a "Very High" category but not a "Very Low" category because the frequency distribution of variability index values for these sets was skewed. These categories enable simple interpretation of any observed variability index value by comparison with those we found. A high or very high variability index value would indicate either a problem with uniformity of application or a field where variable-rate application should be considered.

Table 2. Proposed scale for interpreting amounts of variability.

| Range in Variability Index Values | Descriptive Name | Percentage of Sets |
|---|---|---|
| <10 | Low | 33.0 % |
| 10-14.9 | Medium | 30.5 % |
| 15-19.9 | High | 16.5 % |
| >20 | Very High | 20.0 % |

## Concluding Comments

A set of 10 cornstalk samples collected within each of a few fields can provide information needed to assess the potential benefits of using variable-rate applications to address spatial variability within the field. This information also can be used to estimate the potential benefits of adjusting the average rate of fertilization for the field.

The costs of collecting a few samples to characterize the accuracy and precision of N management are smaller than would be encountered by grid sampling or investing in variable-rate applicators. Relatively few samples can provide reasonable assessments as to whether more intensive sampling is needed.

The value of this method extends beyond the ability to evaluate the potential benefits of variable-rate applications. Mounting evidence suggests that the best N management systems are those that minimize losses of N soon after application. This method can be used to objectively identify N management systems and application techniques that minimize losses of N.

## References

Blackmer, A. M. and A. P. Mallarino. 1997. Cornstalk testing to evaluate nitrogen management. Iowa State University Extension, Pm-1584.